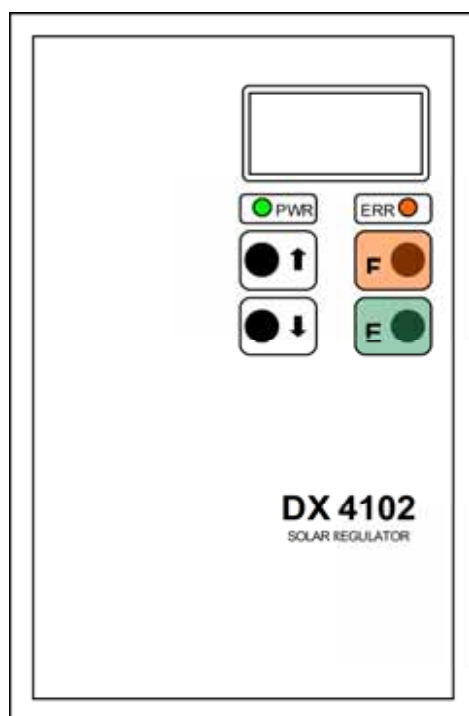


SOLAR SYSTEM REGULATOR



DX 4102.G

User manual

May 2007

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1. Introduction

Regulator DX4102 (in next text regulator or device) is determined to regulation system consists of solar collectors and a warm exchanger to gain warm energy and propagate it to the other systems. Warm exchanger could be for example boiler, water basin or central heating system.

Regulator distributes warm carrying fluid to warm exchanger using actuator (pump) according to set up temperature.

Device is equipped with timing facilities (programmable), which could use subsidiary energy source (electric heating alternatively gas kettle-drum), providing heat limitations in loop. Alternatively device can control secondary loop pump with time delay function.

Device is able to count up the energy given to warm exchanger.

DX4102.G behavior can be set up according to requested system parameters - "programming", Programming uses four keys and Liquid Crystal Display (LCD) located at front panel of the device. There can be found Light Emitting Diodes for power supply indication, system failure.

Regulator is equipped with current loop for data communication with Personal Computer. Software named "EkoSolar" allow user to watch, modify and archive all important data and solar system parameters.

2. Control fundamentals

2.1 Regulation fundamentals

Regulator is one-loop (one-channel) differential regulator. Controlled system consists of solar collectors, heat exchanger (A) and actuator, which distribute warm liquid to exchanger.

Regulator in a forever cycle watches temperatures at the exchanger and compares it with the requested values. To pump warm liquid to exchanger two conditions must be fulfilled (in next text abbreviated start *pump conditions*):

1. Insufficient heat exchanger temperature - measured exchanger temperature must be lower than requested temperature (see "Menu-Temp"), set hysteresis 1 K.
2. Sufficient collector energy - collector temperature must be higher over minimum difference "DeltaON" (see "Menu-Delta") than exchanger temperature to start pump. Pump stops if difference falls below "DeltaOFF" - see 2.1. Parameter "Delta" is needed because of thermal loss in piping between collector and exchanger.

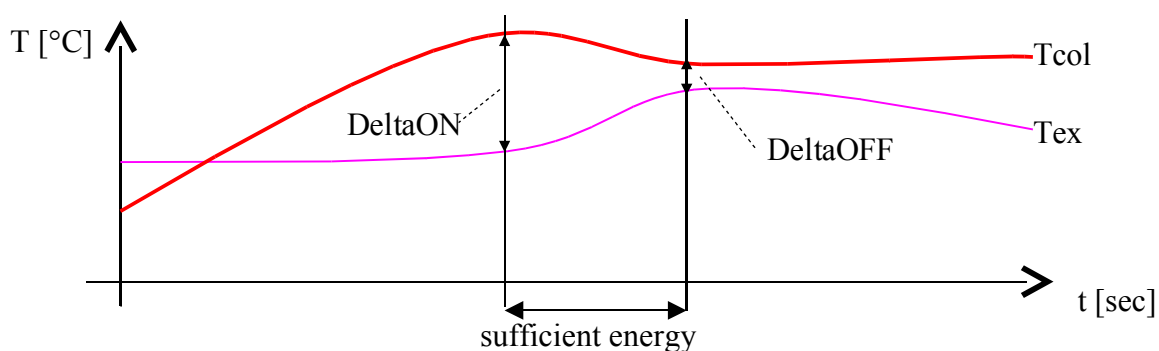


Fig.1 Pump condition – sufficient collector energy

In case the pump conditions are fulfilled (exchanger has insufficient temperature and in collector has sufficient energy), the loop will be switched on e.g. warm liquid will be pumped through this loop. In case the loop has not fulfilled conditions for loading warm, pump stops.

Providing the loop have defined subsidiary energy source ("Menu-Service-Aux.Out=Heating") and exchanger have insufficient temperature, but collector will not have sufficient energy for this loop, it will be enabled subsidiary heating (see chap 2.6), that is time and temperature dependent.

2.2 Pump performance regulation

Device can control the pump performance with pulse-width modulation – to decrease performance the pump is switched of for some tens of milliseconds. Performance regulation is enabled if "Menu-Service-PWMmod" is set up less than 100% (minimal 20%).

Pump performance is controlled (see chap. 2.2) if temperature sinks (collector to exchanger) below DeltaON level. The performance is decreased to **Pmin** till an average value of **DeltaON** and **DeltaOFF**, than it stays on **Pmin** till difference falls below DeltaOFF

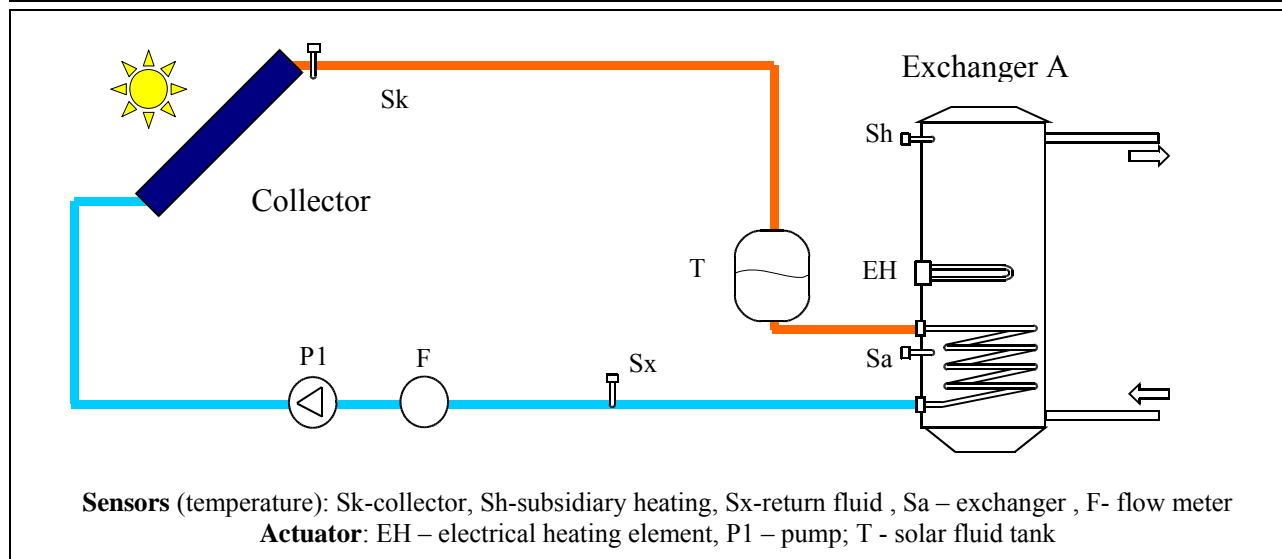


Fig.2 Block scheme of regulated system including subsidiary heating

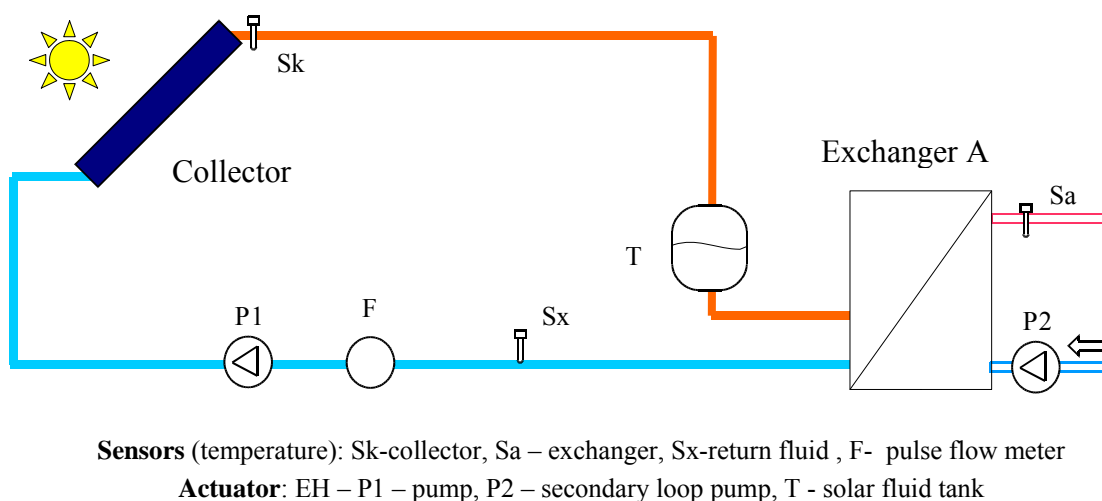


Fig.3 Block scheme of regulated system with secondary loop pump

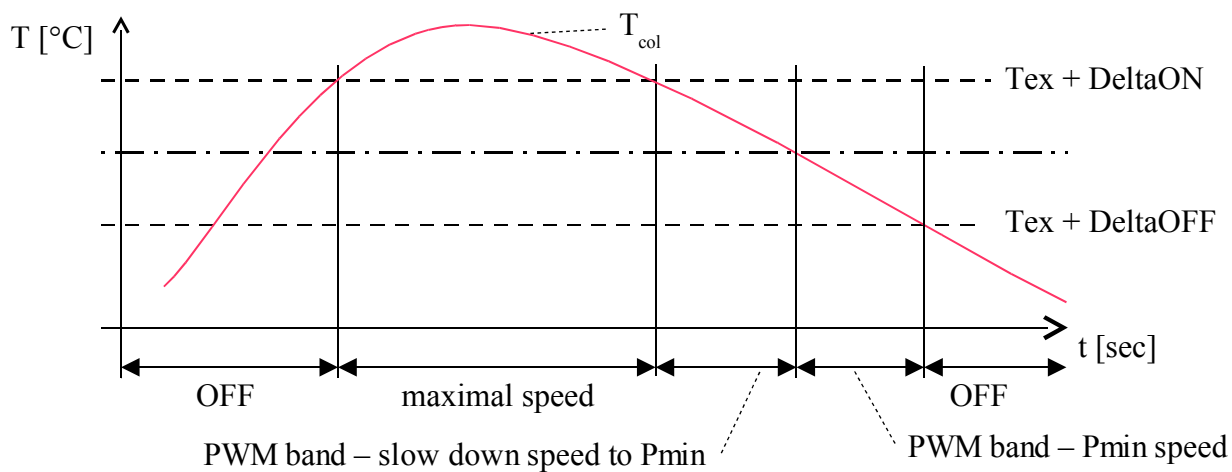


Fig.4 PWM band display – pump performance regulation

2.3 Collector temperature sensing

Collector temperature sensing is made by fixing collector sensor to collector corpus (see menu Service-Sensor) and collector loop is "drain-back" type ("Sensor=Drain").

Drain-back system – is created of collector loop with FILL-in and FILL-out liquid (using solar fluid tank) after an activation condition is fulfilled (collector temperature is over "DeltaT" value greater than exchanger temperature). If it is true the pump is started for defined time **A** at full power (the liquid is transported to collector fields), then the power is slowed down (necessary to keep the flow level) for fixed interval **B** to get system niveau. In the end the collector loop is set to normal process. After the finishing, (loading condition is false), the warm liquid is filled out from the loop to fluid tank.

2.4 Collector overheating

If exchanger is full loaded (has enough energy) and the sun shines it could happen collector overheating. That is why regulator is equipped with „overheating protection“ which can be activated in menu (see chap. 3.2). As the collector temperature increases over 105 °C the primary pump start running till the exchanger temperature reaches **MaxTexc** (see menu Service) or collector temperature sinks below 100 °C. The overheating check stops if collector temperature increases over 120 °C and will be started again if collector temperature falls below **MaxTexc**. This is reasonable if the power (230V) is missing for some time (power failure).

2.5 Auxiliary output

Device is equipped with special output (X/Y), which can be used for cooperation with exchanger or like standalone timer output. In case of exchanger the auxiliary output is used for:

1. subsidiary heating (see chap. 2.6)
2. secondary pump management (see chap. 2.7)

Stand alone timer output - non periodic timer – time window are give by table (see "Menu-Timer"). When configuring use of auxiliary output (see Servis – chap. 3.2) firstly the exchanger is chosen then the way of its using (heating, secondary pump) and after the necessary parameters are set.

2.6 Subsidiary energy source

Device is equipped with time functions ("Menu-Timer"), which is used to rank auxiliary (subsidiary) energy source (electrical heating or gas kettle) for insufficient exchanger heat ("Menu-Service-Aux.Out=A-Aux.Out=Heating"). Auxiliary heating will be activated if (all conditions must be fulfilled):

3. the time window condition is true, see menu "Timer"
4. the exchanger temp. is lower than start temp. (see "Servis-Aux.Out-...-Temp ON")
5. the exchanger (that with auxiliary heating) is not just being selected for warm loading

Auxiliary heating will be switched off, if some of conditions 1. and 3. is false, or the exchanger temperature is higher than stop temperature (see "Servis-Aux.Out-...-Temp OFF"). There is left a possibility to sense temperature in exchanger with another sensor which is fixed in top of exchanger height - see example in Fig. 2 sensor Sh). Physically sensor is connected to S4 position.(see chap 4.2). This function will be activated automatically if sensor is present.

Aux.Out='-', then output XY will be controlled according to item "Timer", it means it is not bound to loop conditions.

Auxiliary energy source will be automatically switched off at High Tariff (energy cost is expensive), if the digital input is set to "Hi.Tarif" (vid "Service-Typ Inp"=" Hi.Tarif ") and corresponding digital input is shorted.

2.7 Secondary loop pump

Regulator is able to use a secondary loop pump for a exchanger "Menu-Service-Aux.Out=Sec.Pump". If this is true then this output is controlled together with corresponding primary loop and it is stopped with preset time delay "Menu-Service-Aux.Out-...-PostPump".

Providing that exchanger sensor is localized at the pipe of secondary loop, the measured temperature is real only for fluid circulating. That is why the regulator manages temperature check function "Service-Aux.Out-...-CheckTem", where the regulator starts fluid pumping in a given period "Service-Aux.Out-...-CheckTem-per", for a given interval "Service-Aux.Out-..CheckTem- on", and it is enabled only if "sunshine" is set up (see chap.2.3

2.8 Regulation failures behaviour

If the sensor failure is found regulator behaves in a following way:

- Collector sensor failure – warm liquid does not stop running (till the fault removing)
- Exchanger sensor failure – the warm carrying fluid is pumped out till sensor malfunction is removed, but only if collector temperature is higher than 60°C
- Subsidiary sensor failure (S4) – subsidiary heating takes as reference value exchanger sensor value (S2)
- Return fluid sensor failure – temperature difference will be set 0 K, it means no instant power (a energy will not be accumulated).

2.9 Energy measuring

Regulator can calculate the energy gained from collector. Energy is counted according the formula: $Q = c \cdot m \cdot dT$, where **c** is relative warm capacity, **m** is mass and **dT** is temperature difference warm carrying fluid (market name Solaren).

Fluid mass is evaluated as $m = q \cdot V$, where **V** is volume and **q** is pumped fluid density (the value is temperature dependent). The volume is either measured by flow-meter (see chap. 3.2) either counted out from time of fluid flow and given flow per a minute.

The temperature difference is given like collector to exchanger output temperature (return fluid sensor needed) or it is fixed difference set by DiffTemp (see chap.3.2). For the second case the measuring is for informative purpose only.

Relative warm capacity and fluid density is assumed for SOLAREN (non diluted) !

Energy is counted up as cumulative number increasing for each period. Counter can be cleared manually by user see "Service-Energy-Clear Ac" or "Records-Counter-date nul". After reaching 10000 kWh it is cleared in automatic way. Day registers (32 days backward) - keep energy for each day. The records can be seen in "Records" menu (chap.3.2).

Instant collector power represents (gained) energy amount per fixed period. Periode is given as the delay between two flow-meter pulses or is set fixed one minute.

3. Service manual

3.1 Device description

Regulator consists of (seen from the front panel) LCD display (two rows per 8 characters), a four key keyboard (KBD) and LED indicators (PWR a ERR), see Fig. 6

With display and keys user can get an information about regulation status, find out measured and requested values or edit parameters and so on. Parameter accessing is realized by menu structure.

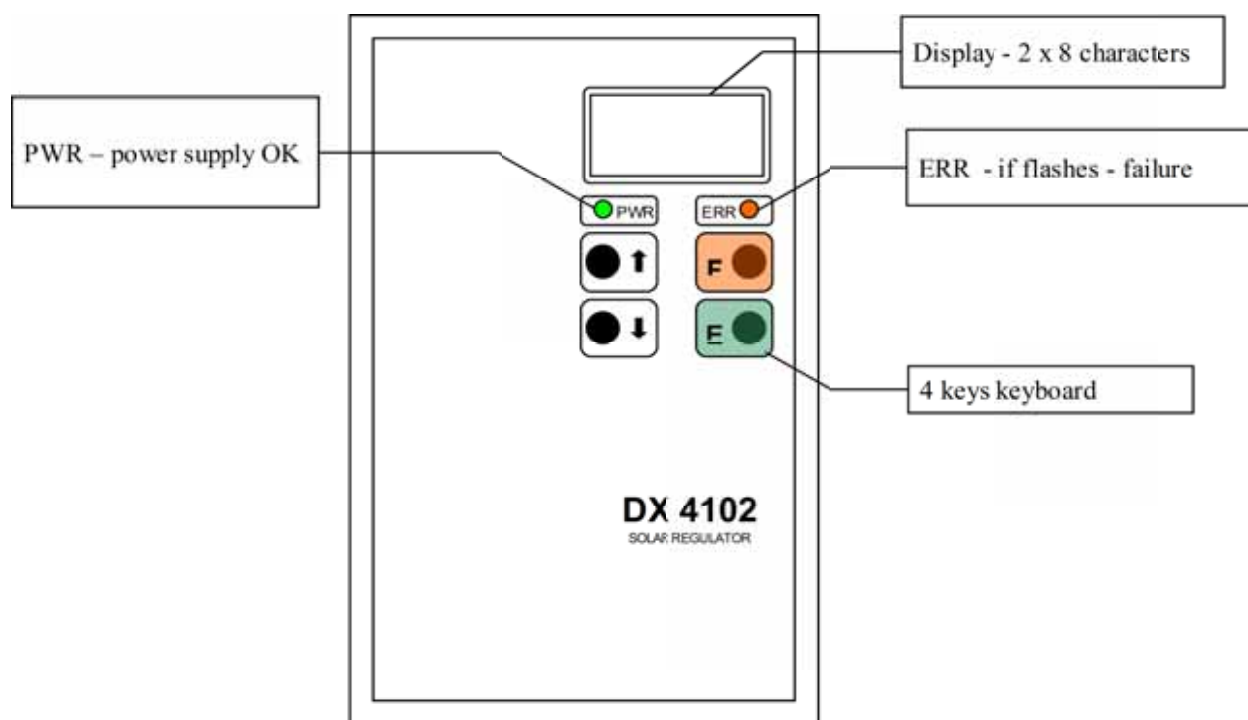


Fig.5 Regulator front panel

Keyboard is represented with a group of four keys. The meaning of keys follows:

F ...Function key – quit without change for editing (Escape) a return to upper level

E ...Enter – confirmation for editing value (Enter) – stores value and moves to next item

▲...menu items change in defined direction, press = +1, hold dynamic value increasing

▼...menu items change in defined direction, press = +1, hold dynamic value increasing

▲, ▼ at the same time pressed – setting up minimal value for selected parameter

Two light indicators signalize:

PWR – power supply presence

ERR - system failure (ERR flashes) – sensor or internal regulator failure see chap. 3.4

The processed values can be seen in two display windows. Window change involves "E" key see 3.1, window description can be found in chap.3.3. Pressing "F" key enables menu display for requested regulation parameters, date, time and service parameters. Detail menu description covers chap 3.2.

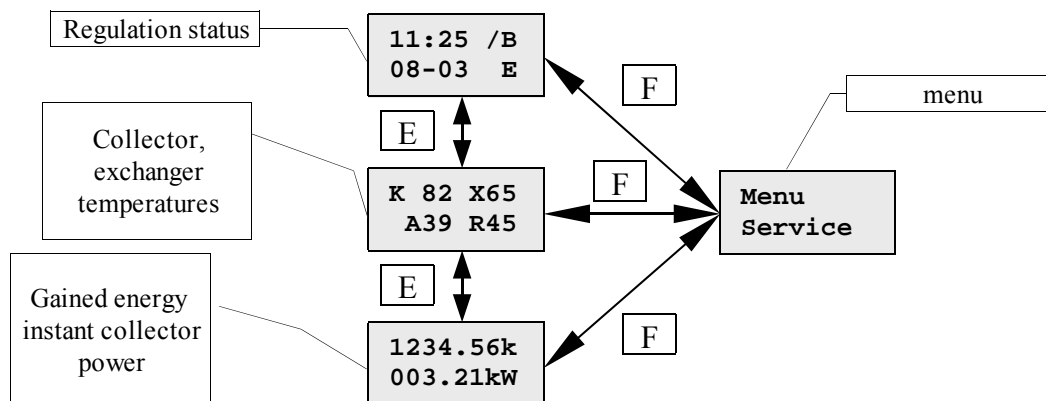


Fig.6 Regulation status versus menu

3.2 Menu structure

Menu is involved by pressing "F" key if regulation process display is active. Menu items can be selected by ▲, ▼ items, confirmation enables "E" key, current level quits "F" key. Changed item is flashing. After reaching the maximal value the minimal is set and vice versa.

Menu items

- ◆ **Date** date setting. Firstly day in a month, then month and in the end the year. If date is set incorrect (30.02.2004) cursor () returns back to day of month position.
- ◆ **Time** time setting. First is set summer (S) / winter (W) time then hours and minutes in the end. Choosing summer or winter involves time the hours are set up automatically.
- ◆ **Timer** timer setting - maximal 8 time interval during a day (00:00-23:59). First time to switch on, then switch off (value 24:00 represents switch off at 00:00).
- ◆ **Records** day gained energy records (see Fig.9)
 - Counter shows cumulated energy (from time of last clearing)
 - Energy.QH gained energy corresponding to last quarter of an hour
 - Energy.D gained energy for last 32 days (each day individually)
- ◆ **Manual** manual setting outputs of regulator – three modes: "Aut" = controlled by regulation algorithm, "ON" – always ON, "OFF" – always OFF
- ◆ **Delta** setting start and stop difference for exchangers (Kelvin values). Start difference DeltaON is minimal temperature difference (collector to exchanger temperature) to start pump running. Stop difference DeltaOFF minimal value to stop pump.
- ◆ **Temp** exchanger requested value (°C)
- ◆ **Service** service parameters setting

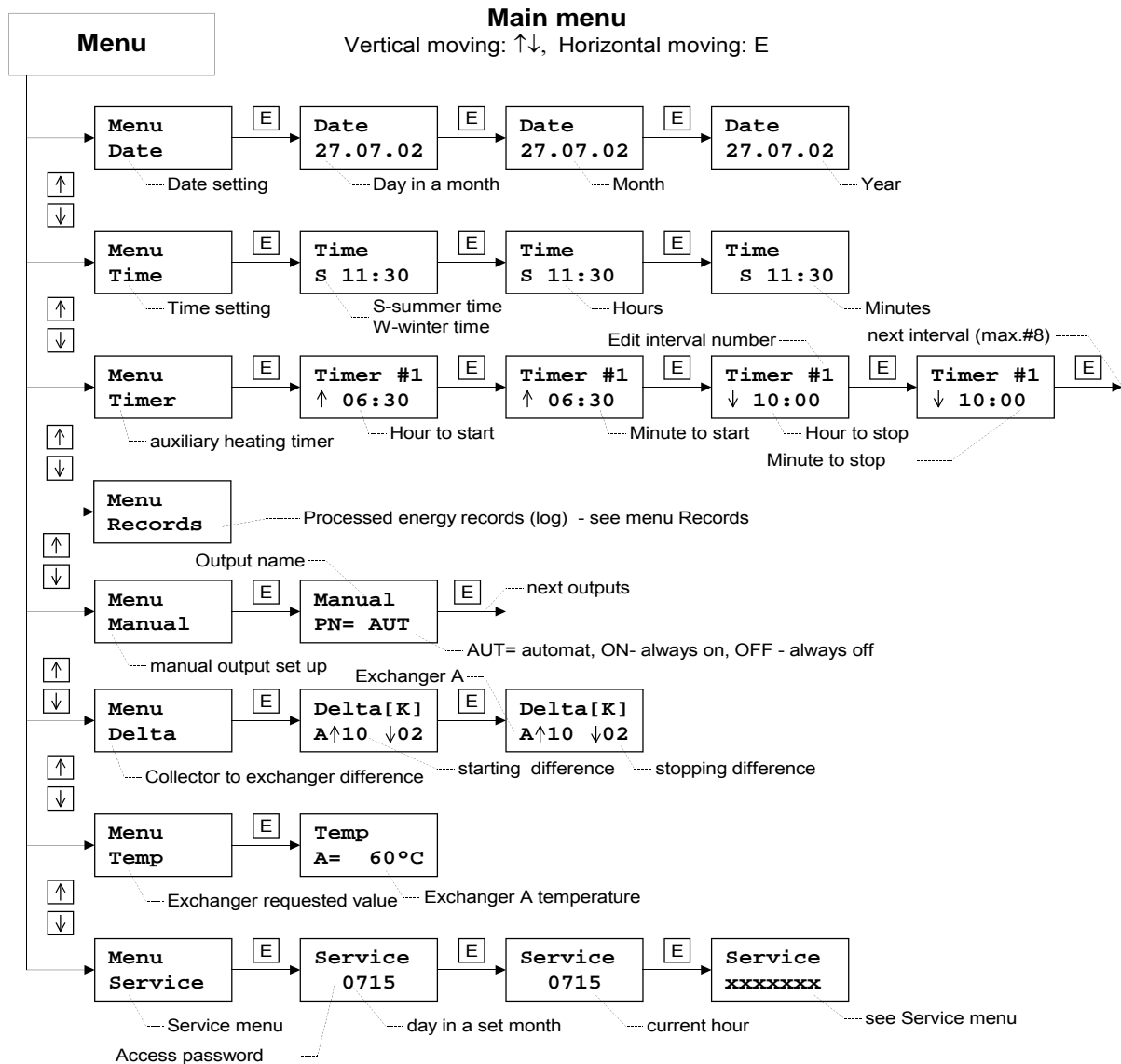


Fig.7 Regulator menu

Service setting

Service menu access is protected by knowledge of code. Service settings should be set at beginning (first installation) that is why the password is "ddhh" needed (dd day in a set month and hh hour set in device). Service menu items::

- ◆ **Sensor** collector sensor localization (see chap.2.3). There are two possibilities:
 - **Drain** at collector corpus (see chap. 2.3)
 - **Delta T** temperature difference
 - **Time A** power maximal (fill in) time
 - **Time B** power minimal (stabilize flow) time
- ◆ **Prot.Col** collector overheating protection (Enable=Yes, Disable= No). If enabled next parameter appears MaxTec.
- ◆ **Aux.Out** auxiliary output XY definition. Firstly must be defined exchanger (if none XY output will be by "Timer" variable controlled), then the purpose must be defined: heating (see 2.6) or secondary loop pump (see 2.7). For heating the start and stop times are set, for secondary pump off time delay and pipe sensing items (similar to collector pipe) see "Sensor- Pipe"
- ◆ **PWMmod** actuator pump performance (see chap. 2.2) for A loop (20-100%). 100% means full pump speed.
- ◆ **ParEnergy** parameters for gained energy from collector panels (see 3.2):

- **Flow** flow meter setting – if pulse flow meter is used (Flow imp=Yes), flow is set up in liters / pulse, if no flow meter is used then in liters / pulse.
- **BackTemp** return fluid sensor using (No/Yes = used), for no sensor it is recommended set up temperature difference of collector (between output and input).
- **Clear Ac** clears gained energy counter (accumulator)tupom).
- ♦ **Com.par** serial line communication parameters: address and baud rate
 - **adr** device address (0-19). Important for more regulators at the line, otherwise 0.
 - **S** baud rate (1200, 2400, 4800 or 9600 Baud)
- ♦ **Mode I/O** input / output parameters
 - **Inv.Out.** output: Direct ("Norm") or inverted ("Inve"). If inverted and it is a demand to switch on, the output will be switch off and vice versa.
 - **Inv.Inp.** digital inputs D1 and D2 ("Norm"/"Inve") – if NORM active for short, otherwise active for open circuit
 - **Using D2** Digital input D2: "no use" – free, "Sunshine" – extern light intensity sensor, "Hi.Tarif" – disable electrical heating if High tariff signal appears

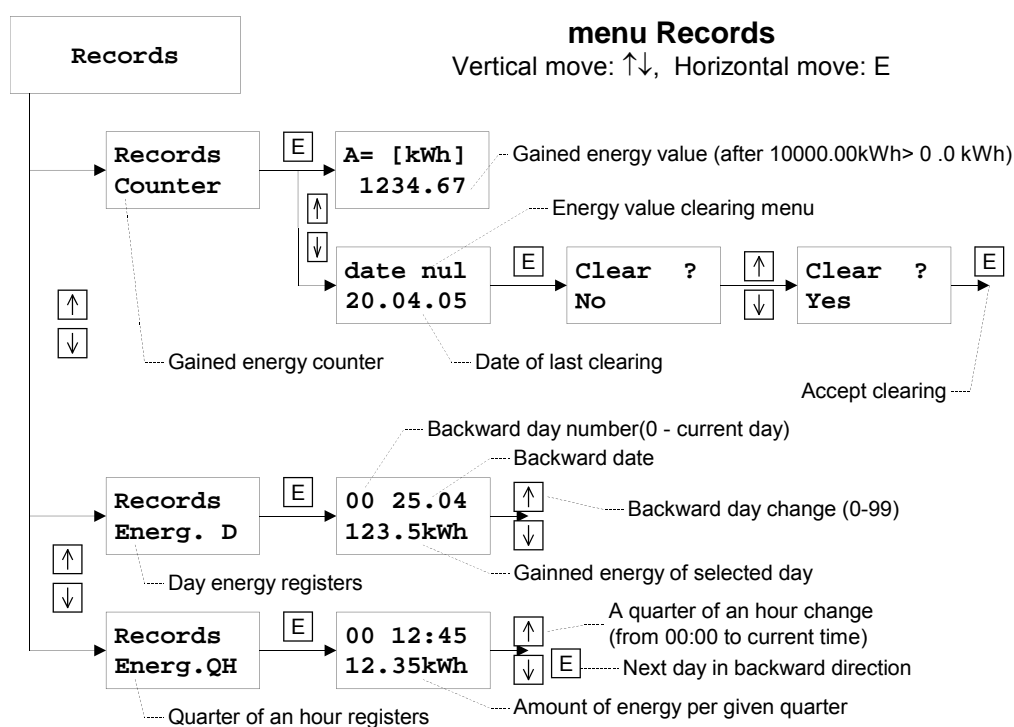


Fig.8 Menu Records

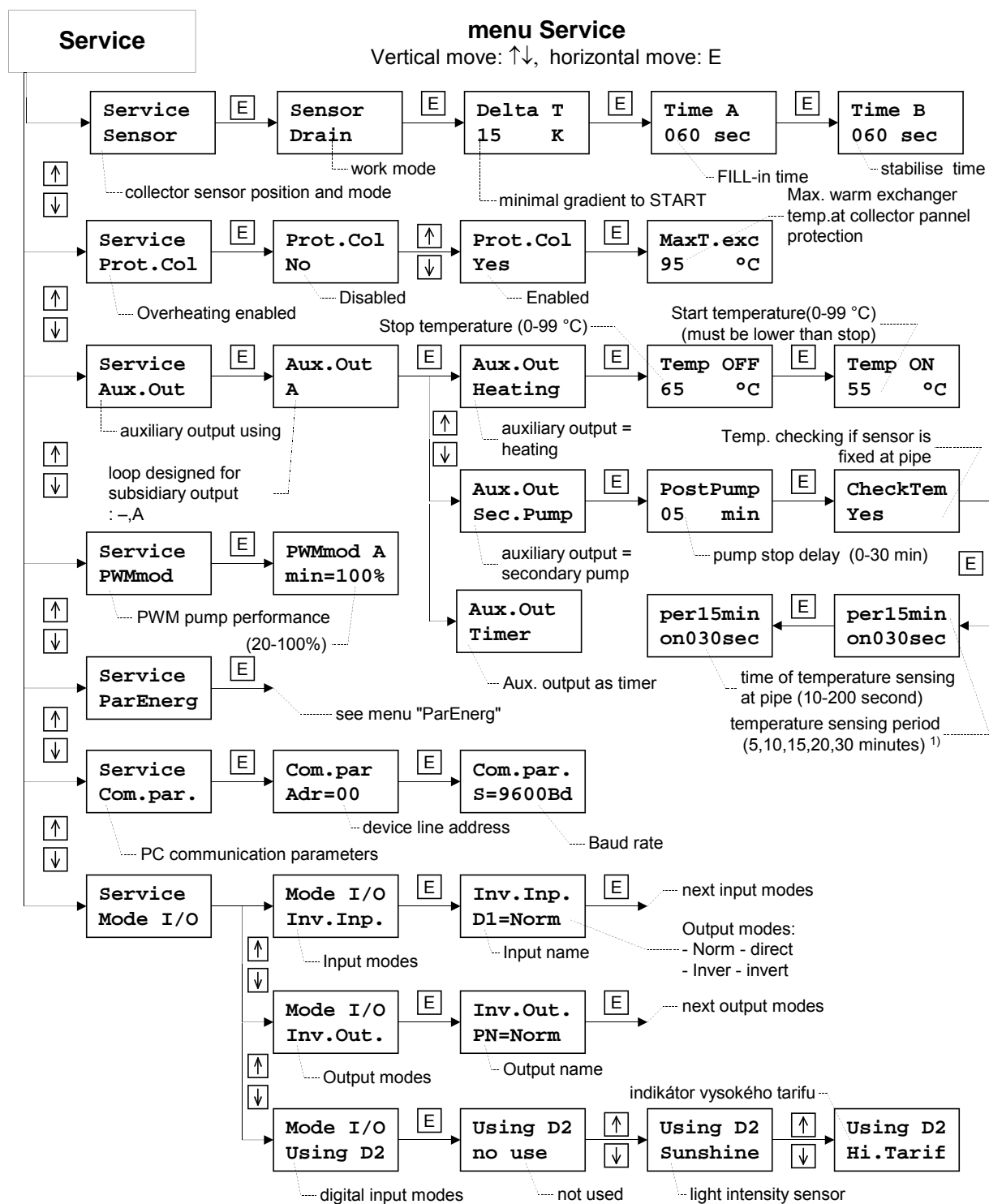


Fig.9 Menu Service

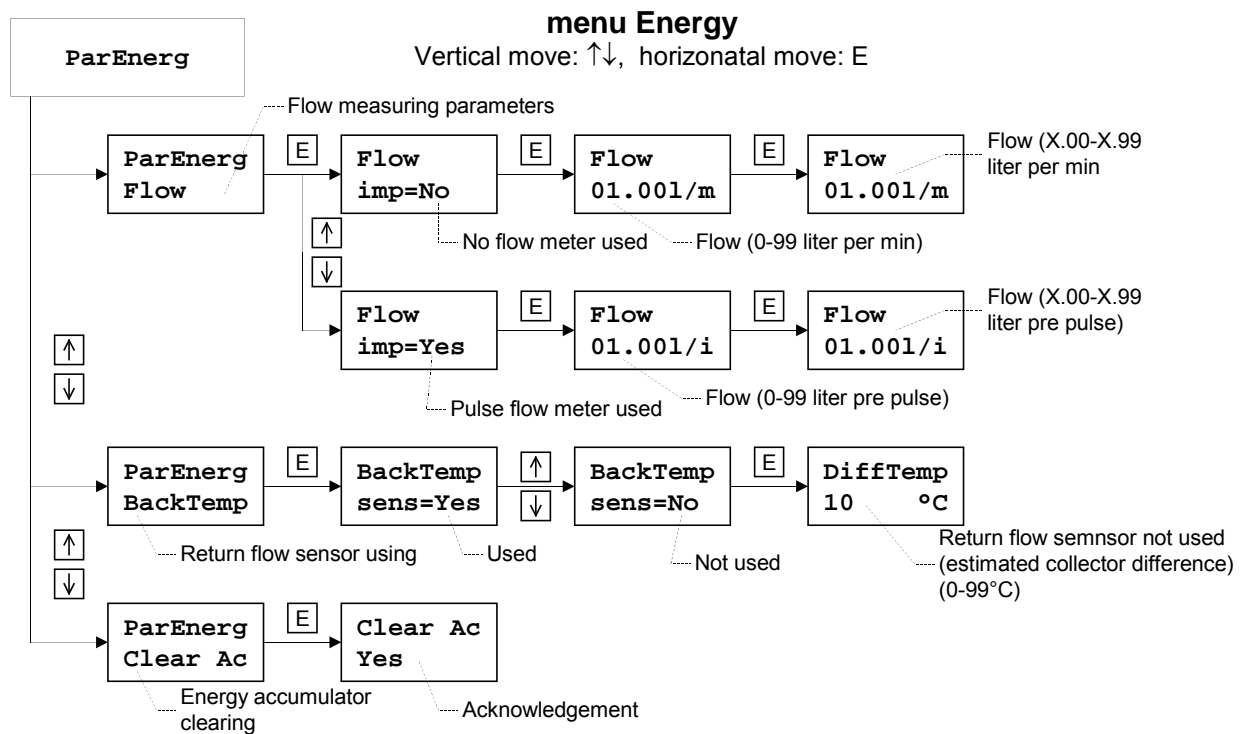


Fig.10 Menu Energy

3.3 Regulation status display

Regulation status

The upper line displays: time and loop activity – if loop works, the rotating icons and the name of the exchanger (A) and the flashing character representing non standard warm pumping: 'p'- the pipe temperature sensing (sensor at the pipe), 'e' – sensor failure, 'H' – collector overheating.

The lower line displays: date and the character representing X output status ('E', auxiliary energy source, 'S', secondary loop pump, 'T', only timer), and failure report, if any happened.

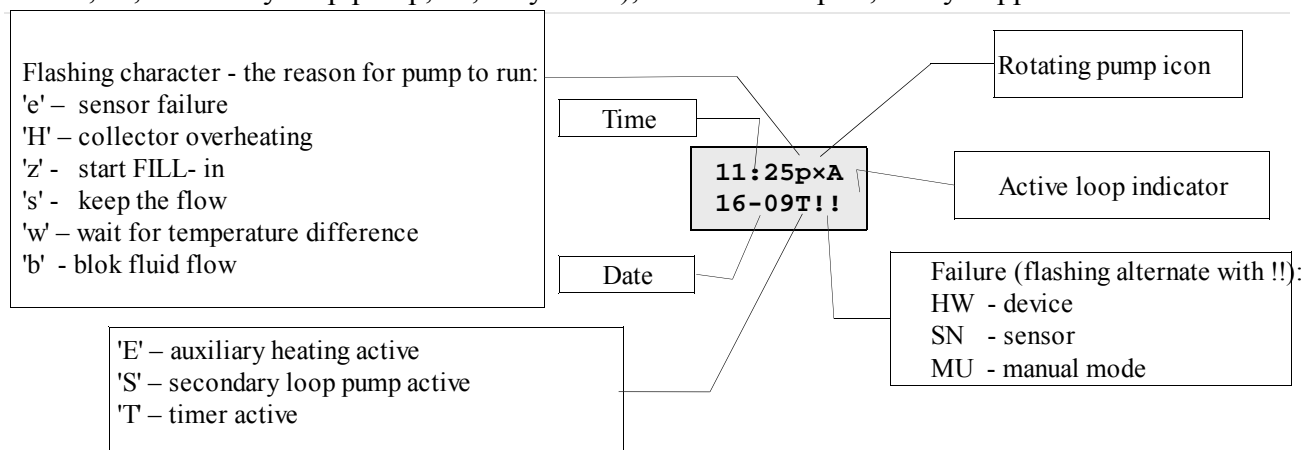


Fig.11 Regulator status

If system detects a failure, the double „!!“ alternates flashing with code of the failure.: HW- hardware error, SN – sensor error, MU – manual mode.

Loop and collector temperatures

The first line displays collector temperature, the lower one exchanger temperature. If the return fluid sensor is used, its temperature appears too.

For short circuit sensor flashing 'x' appears, for open sensor circuit '-' appears and if the temperature is less or greater then display width then flashing '9' appear.

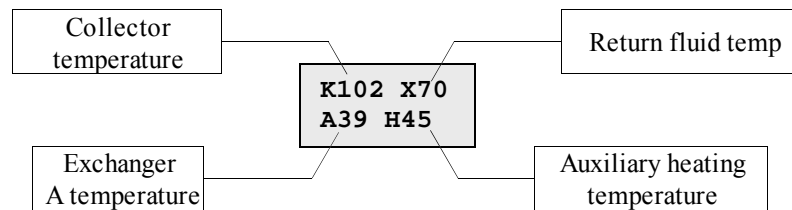


Fig.12 Temperatures display

Energy and power given by collector panels

Upper line displays energy (kWh) propagated from collector from last clear (see Records). Lower line keeps instant power (kW) of collector panels. (see 3.3).

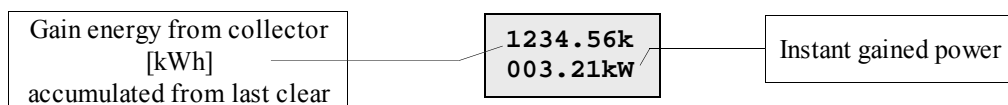


Fig.13 Energy and power of collector panel

Through pressing the arrow keys (at keyboard), next window appear. There can be seen temperature difference and computed value of flow converted to minutes (liters per minute).

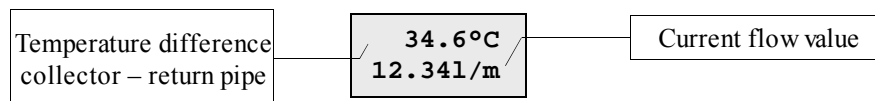


Fig.14 Temperature difference and flow value

3.4 Failure warning

If some failure happened, the ERR light start to flash and display shows the error code (see chap.3.3).

There are two main failures - system failure, sensor failure:

1. Sensor failure: instead of temperature value the "-" (open circuit sensor), "x" (short circuit sensor) or "?" (Analog to Digital Converter failure) character flash. The error code "SN" flashes.
2. System failure: ADC failure instead of temperature "?" flashes, Real Time Clock failure instead of time and date "?" appear. The error code "HW" flashes.
3. Manual mode: if some output should be switch on and it is not possible because of manual switch position, regulator shows flashing "MU" to annotate user.

4. Installation directions

4.1 Device dimensions

Device is fixed at wall through metal console, that must be first installed. Regulator is manufactured in form of plastic box (125x83x35), that fixes at mentioned console..

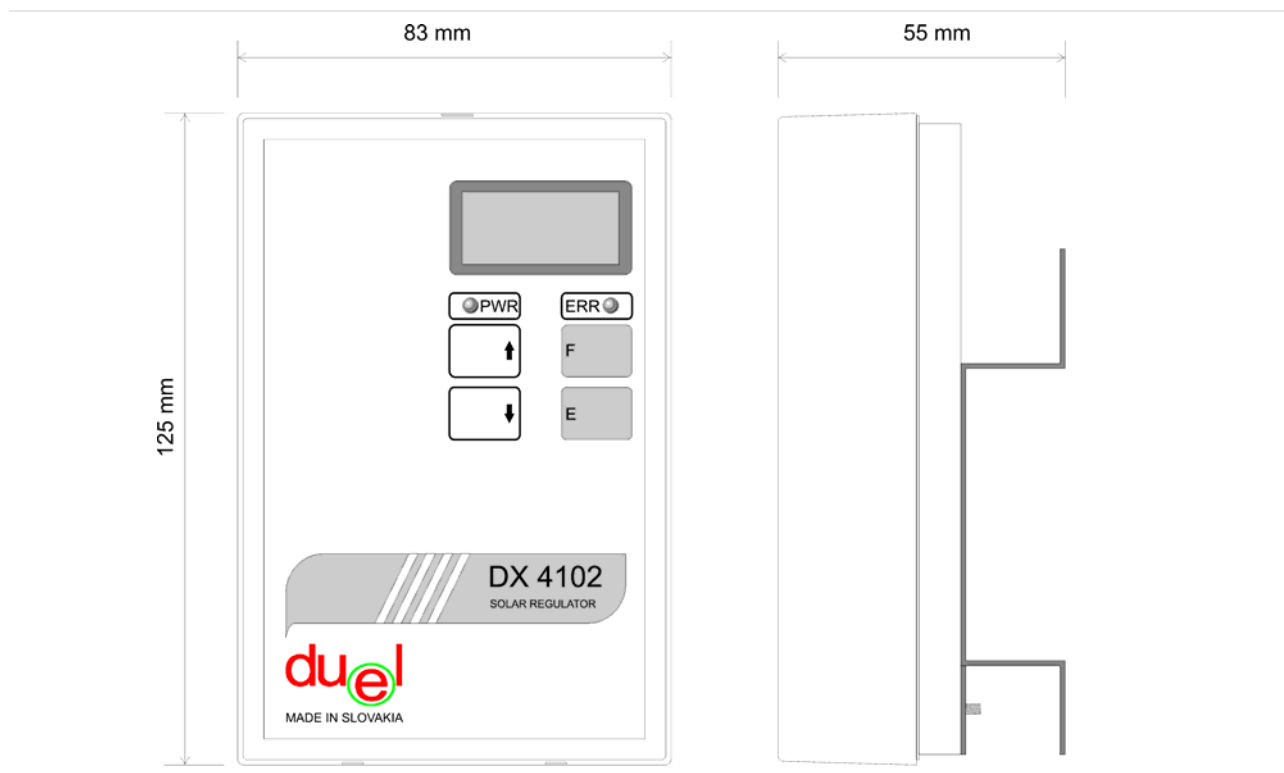


Fig.15 Device dimensions

4.2 Wire connections

Regulating system consists of: regulator, sensors and actuators (pumps). Sensors and actuators are connected to installation bracket, localized under the cover of the device.. Wiring diagram is given in.

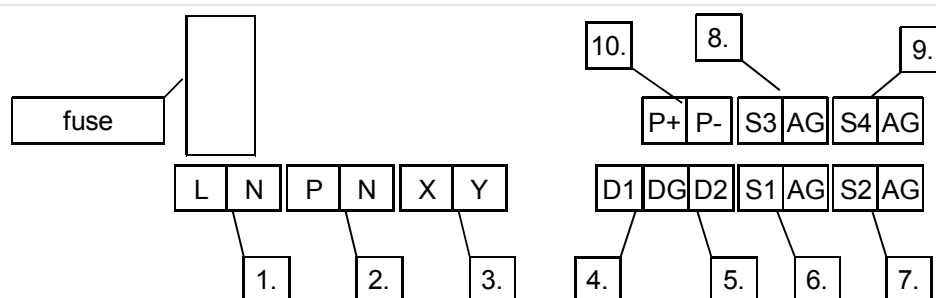
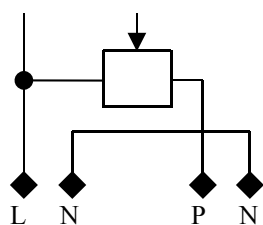


Fig.16 Wiring diagram

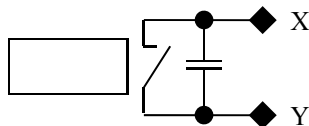
1. power supply 230V~ (1)
2. output PN (2) – pump
3. potential- free output X / Y (3) – auxiliary output (4)
4. D1 digital input – pulse flow meter
5. D2 digital input - not used, High Tariff ("HiTariff"), sunshine ("Sunshine")
6. S1 collector temperature sensor
7. S2 warm exchanger temperature sensor
8. S3 return flow temperature sensor
9. S4 sensor for auxiliary output
10. P+, P- communication line PC (current loop 20mA)

Notes:

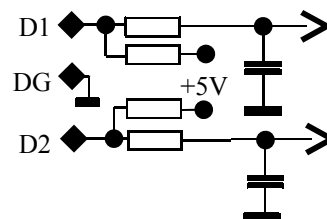
- 1) The current flowing in this wire goes through fuse to PN output. !! Warning for the current value which is limited by fuse. Power actuators should be connected using additional relays or power relays!
- 2) As switching element used triac, power output 230V AC, maximal 1A
- 3) Relay contacts, 230V AC, 30V DC. Current limited to 1A - directly may be used load with dissipation max 230W (@ 230V~), if more power is required an additional relay or power relay must be used!
- 4) Auxiliary output may be used for: additional heating or secondary circuit pump or timer only



a) P(ump) output



b) X / Y output



c) digital inputs D1, D2

Fig.17 Input - output equivalent connections

4.3 Installation instructions

An installation of the device should be made according to recommended application scheme keeping following rules:

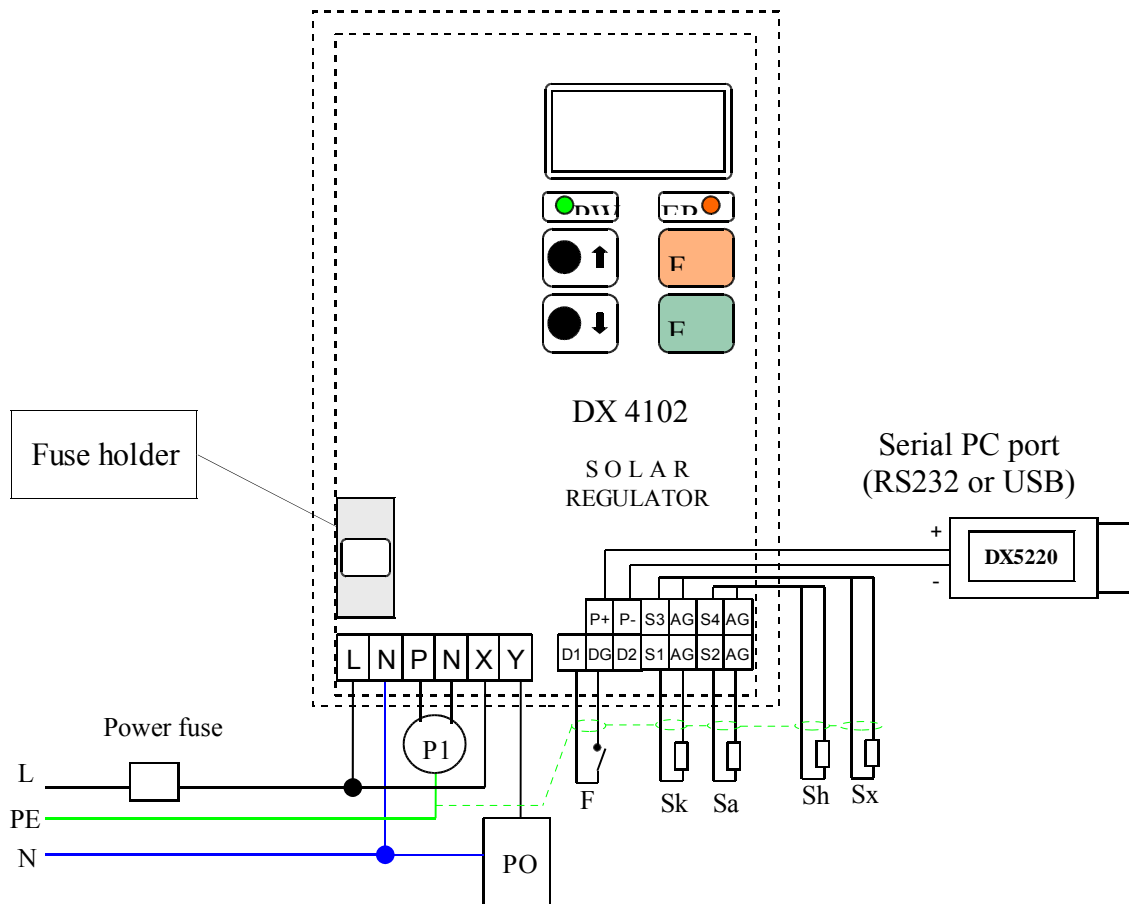
1. Firstly sensors, then actuators and in the end power line. For sensors is recommended twisted pair line (MK 2x0.75/TP 03/41/MTP 226/70), keeping distance from power wires (min.30 cm) and shield connect to PE wire.
2. Before screwing wires to terminal, put the sleeve endings to the end of the wires
3. Just before power supply connection check all input and output wires (sensors, actuating terms) for disconnection or short-circuit
4. Turn on the safety fuse and test function of actuators in manual mode
5. Check measured temperature values at collector, then in the loops and set initial system parameters.

4.4 PC connections

Device offers possibility for connection to serial port of personal computer. This connection enable user to:

- * comfortable set up all parameters of regulation
- * not limited keeping records of gained energy
- * watch regulation process from the living room „sofa“ and supervisor regulation

From the hardware side of connection, there is a necessity for communication (physical layer converter for RS232 \Leftrightarrow 20 mA current loop) converter DX 5220, which is connected with two wires to connector field (P+, P-). Keep polarity during connection, right connection forces LED in DX5020 to light (pins of DX5020 should have about 2.7V), wrong connection (0,7V).



Sensors: Sk – collector temperature, Sa – exchanger temperature, Sx – return flow, Sh – auxiliary heating
 Actuators: PO – power relay, that controls auxiliary heating (3 phase heating element), P1 – pump
 Flow measuring: F -flow-meter connected to digital input
 Note: installation bracket and fuse holder are under the top cover

Fig.18 An example of regulator connections

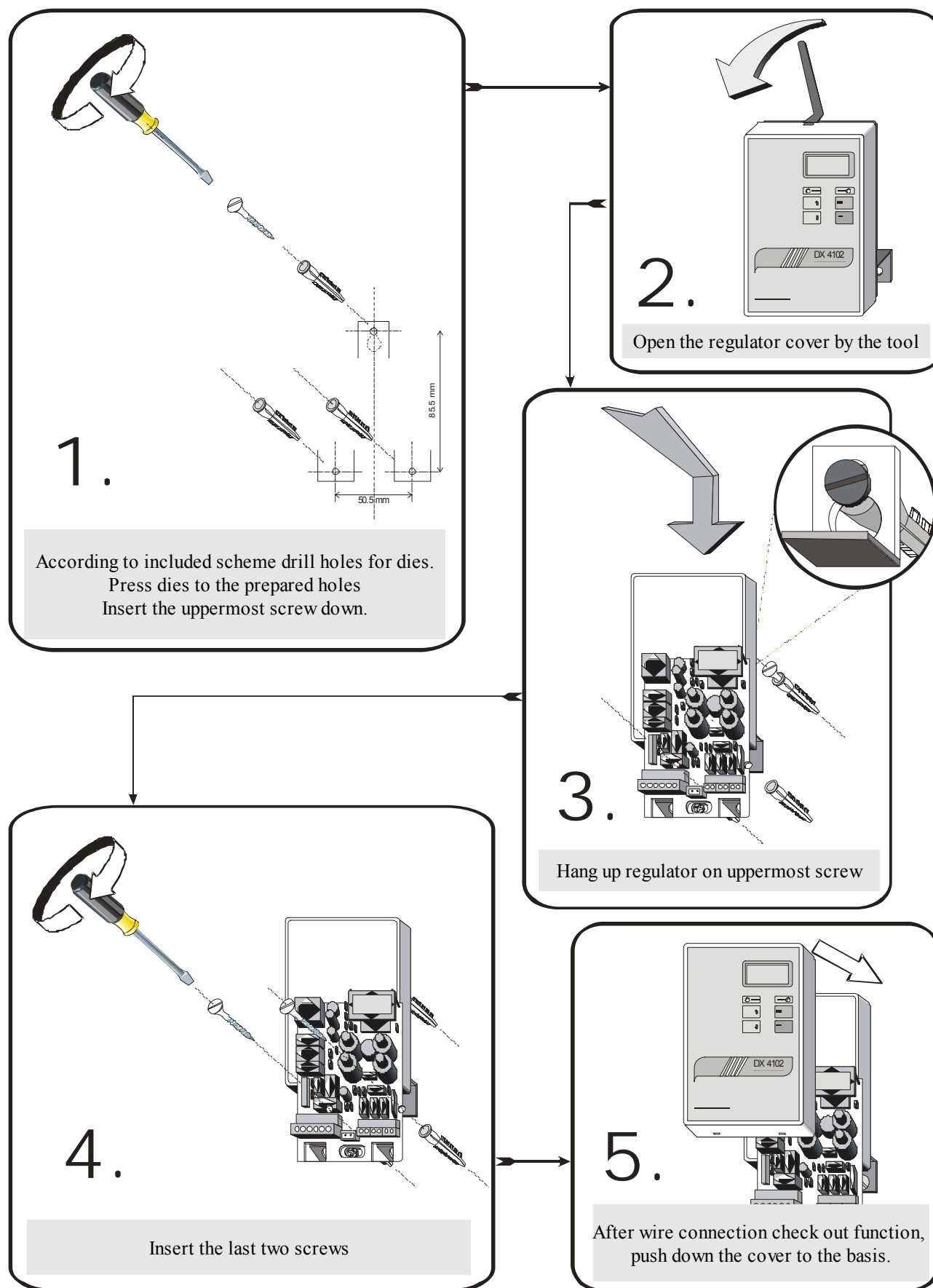


Fig.19 Device assembling

5. Technical data

Power supply:	230V/50Hz
Power rating:	230VA
Output voltage:	230V/50Hz
Output current limitation:	1 A
Fuse rating:	2 A, type T (slow reaction)
Sensor temperature range:	-25 ÷ +170 °C
Sensors:	DX 1083 (DUEL Námestovo, [1000 Ohm @ 25°C, 1670 Ohm @ 100°C])
Difference range:	0 ÷ 25 K
Temperature accuracy:	± 1.5 K
Time back up:	7 days
Insulation protection:	IP20

Operating ambient conditions.

Ambient temperature:	5 ÷ 50 °C
Air humidity:	max 90% @ 30°C
Air pressure:	70 ÷ 106 kPa

Warranty:

- Manufacturer provides guarantee 36 month from the day of delivery
- Warranty refers only to the fault, which come into being by normal operation with sensor delivery. Do not refer to fault, which arises by inexpert service, incorrect storage, unsuitable environment and high power activity (spontaneous disaster, flood, fire, atmospheric discharge and so on.)
- User loses claim to warranty at devices, on those was execution hit
- Warranty also after-warranty service guards manufacturer

Notes:

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